Exposure of BSO crystal by using Laser Beams withWavelengths 532 nm and 633 nm

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Abstract:

BSO crystal was subjected to laser radiation with different wavelengths . The effect of changing degree of polarizer on signals that were recorded when crystal exposed with continuous -laser beams (532nm ,633nm) has been discussed . Lasers at 532nm (Nd:YAG) and 633nm (He-Ne) are used ,and the influence of each type was studied . Pulsed-laser beams 532 nm to exposure BSO crystal was used also .These laser beams have more effect than the other because of their high intensity.

Keywords: light-induced absorption, photorefractive materials, BSO crystals, photochromic effect.

تشعيع بلورة BSO باستخدام أشعة ليزرية بالأطوال الموجية 523nm,633nm

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الخلاصة:

تعرضت بلورة BSO الى اشعاع ليزري باطوال موجية مختلفة، ان تاثير تغير درجة المستقطب على الإشارات المسجلة بواسطة الاوسيليسكوب عندما تعرضت البلورة الى اشعة الليزر (532nm,633nm) درست ونوقشت . الليزر ذو الطول الموجي 532nm (Nd:YAG) والليزر ذو الطول الموجي (He:Ne)633nm قد استخدمت، تاثير كل نوع تمت مناقشته. أستخدم ليزر Nd:YAG النبضي (532nm) لتشعيع البلورة .هذا النوع من الحزمة الليزرية كان اكثر تاثيرا بسبب شدتها العالية.

الكلمات المفتاحية: الضوء المحتث الممتص، ألمواد الكاسرة للضوء، بلورات BSO ، ألظاهرة ألفوتولونية.

1. Introduction

Because of their high photosensitivity to light beams and presence of charges carrier mobility[1,2,3],BSO crystals are taken as an efficient photoconductors. BSO and BGO crystals are considered as perfect photoconductors because they have low dark conductivity that permit to increase large photo-induced space-charges. The photoconductivity and their electrooptic spectral properties allow to improve and create a wide range of optical devices and systems[4]. The light induced absorption and relaxation time life for electrons may require several seconds to several days depending on different sillenite crystals[5]. BGO, BSO and BTO are renowned for their notable piezoelelectric, exceptional acoustooptic, and extraordinary electrooptic materials[6]. BSO crystals are used, due to their efficiency, in different devices and systems including spatial light modulators, dynamic real-time hologram recording devices, phase conjugation wave mixing, optical correlators, and optical laser systems for adaptive correction of ultra short light pulses. The process of photo-induced absorption makes possible to improve and manufacture different types of optical devices such as optical modulators, switches etc[4].

The term sillenite compounds refer to a group of materials, which have common structural aspects to γ-Bi_2O_3. These compounds are very well acknowledged since early 1970s, when the first group of crystals were grown through using CZ technique. The structure includesBi_2O_3, as the primary oxide compound, more than 60 single crystals were obtained, while the second oxide is a tetravalent oxide-general formula MO_2 with M= Ge, Si, Ti –such as GeO_2, SiO_2, and $TiO_2$are the most common compounds. The two oxides have general ratios between them as 6:1 and 2:3, which gives the formulas $Bi_{12}MO_{20}$ and $Bi_4M_3O_{12}$. Nevertheless, this ratio can mainly differ according to the phase diagram. While other double oxides as $Bi_xM_yO_z$ are also known, where the cation M can be Ga, Zn, Ba, etc, in which the ratio of the two oxides different from that previously mentioned [7]. Moreover, bismuth sillenites $Bi_{12}MO_{20}$ (BMO,with M= Si, Ge, Ti represent a tetravalent ion, which holds a tetrahedral location in a body-centered cubic cell within space group I23[8,9]. Bismuth Silicon Oxide can be briefly described as a light yellow, which has photoconductive electro-optic crystal where it is found increasingly applicable in Pockels Readout Optical Memory (PROM), thin film optical waveguides, Photo-refraction and Phase Conjugation[10].

2. Excitation of photo-induced absorption in $\mathbf{Bi_{12}SiO_{20}}$ crystal

In order to explain the experimental results, the suggested theoretical model had a diagram of energy levels band gap as shown in fig(1). The band gap energy of BSO crystal equals to 3.21 eV [11]. The position and life time of electrons in the levels depend on the defects in the crystal structure and its impurity concentration [12]. The electrons are stimulated by laser beams and go back to certain levels in band gap or to the valance band. The change of the concentration of electrons in the levels is described by the following equations:

$$\frac{\partial N_1}{\partial t} = aI^2 + N_2 I - r_{31}N_1(N_1 + N_2) - r_{32}N_1(1 - N_2) \quad (1)$$

$$\frac{\partial N_2}{\partial t} = -IN_2 + r_{32}\, N_2(1 - N_2) - r_{21}N_2(N_1 + N_2) \qquad (2).$$

$$\alpha = N_1\delta_{N_1} + N_2\delta_{N_2}$$

N_1, N_2 are the concentration of the charge carries(electrons) at the levels in conducting band and at levels in band gap respectively . δ is ionization cross section, r_{31}, r_{32}, r_{21} are recombination coefficients,a is a constant, α is absorption coefficient. I is the intensity of light . The photo-induced absorption in BSO crystal is illustrated by figure1.

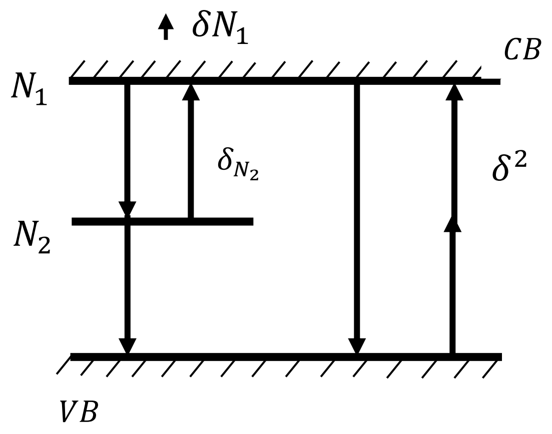


Fig.1 Schematic illustration of electron transition between levels in BSO crystal .

3. Experimental method and rsults:

The effect of changing degree of polarization was studied on transmitting light in 2.2. mm-thick pure silicate oxide crystal irradiated by 532nm from Nd:YAG laser and by 633nm from He:Ne laser. BSO crystal was exposed with continuous laser beams (the intensity range was 1 - 15 MW/cm^2), the degree of polarization of laser was measured by polarizer .The signal has been recorded by the oscilloscope TDS-2022B. Fig.2 shows the experimental setup and devices that used in present study. BSO crystal was exposed with pulsed-laser beams (the intensity range was 0.1 - 150 MW/cm^2).

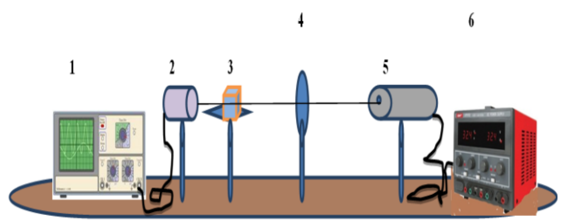


Fig.2 A scheme of experimental setup for exposure BSO crystal:

1-Oscilloscope, 2-Photodiode, 3-BSOCrystal, 4-Polarizer, 5-Lasertube, 6-Power supply

figure 3 illustrated exposure of BSO crystal by laser beams(633nm).The degree of polarization of incident light was changed from 20 (figure 3a) to 70 (figure 3d). It was noticed that the signals recorded increased with the increasing degree of polarizer. The readings of the signals on the oscilloscope were from 0.64 V to 3.3V. Figure 3a shows that the signal is 0.64 V when polarization is 20.These readings of signals increased to 1.55V (figure 3b) when polarization is 40. From figure 3c it was noticed that the signals are 2.8V when degrees of polarization is 60. The exposure of BSO crystal by laser beams(532nm) was shown by figure 4, and we noticed that the changed degree of polarizations was from 20 (figure 4a) to 70 (figure 4d), the absorption decreased with the increase of these degrees and the reading of signals that we recorded by oscilloscope changed from 0.64 V to 5.4 V (figure 4d). In figure 4b, the reading of polarization is 40, when the signal is 2.4V and then polarization increased to 60(figure 4c), the signal also increased to 4.4 V .When applying continuous laser beams (633nm and 532nm) on crystal BSO. The excited electrons and the use of these lasers led to move electrons to valance band. Later we exposed a photorefractive Bi12SiO20 (BSO) crystal with high intensity pulsed-laser beams 532 nm (figure 5), the change of signals was from 54V to 310 V for the same degree of polarizer of continuous laser beams (532nm.633nm). This means the type of lasers have more effect to transfer of electrons in the conduction band. Figure 5 showed that the changed degree of polarizer was from 20 (figure 5a) to 70 (figure 5d), the absorption decreased with the increase of these degrees and the reading of signals that was recorded by oscilloscope changed from 54 V to 330 V (figure 5d). In figure 5b, the reading of polarizer is 40, when the signal is 180V and then polarizer degree increased to 60(figure 5c), the signal also increased to 310 V.

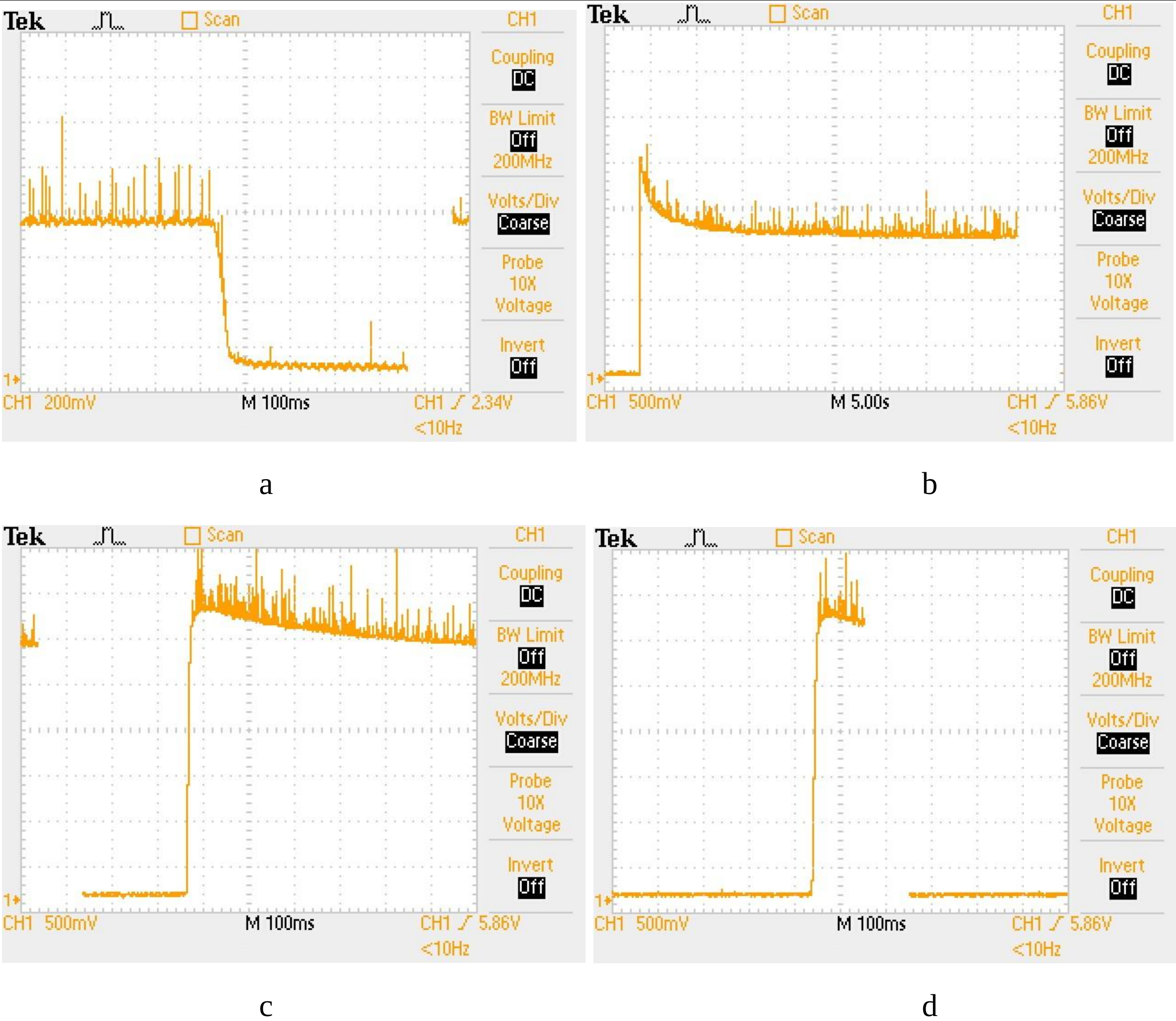
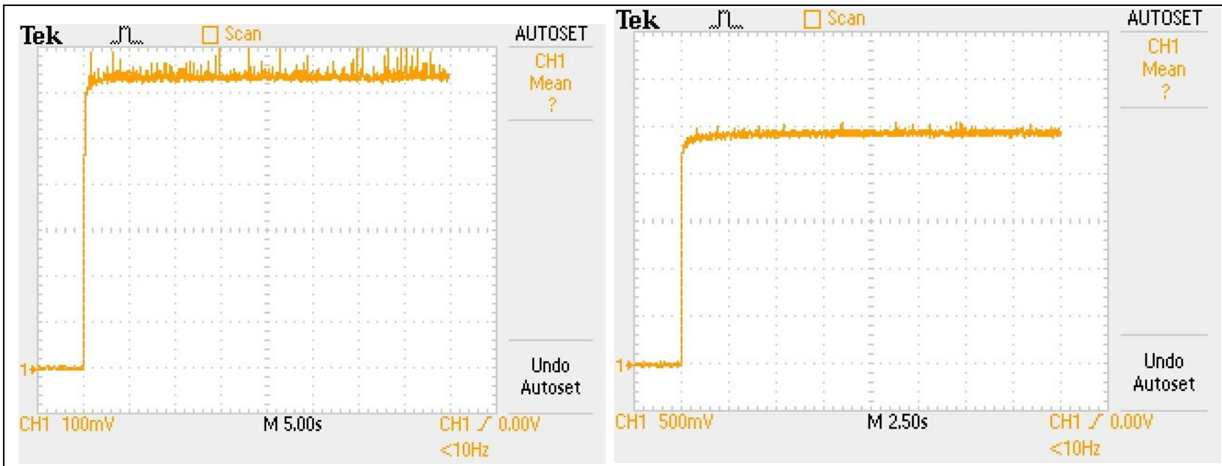
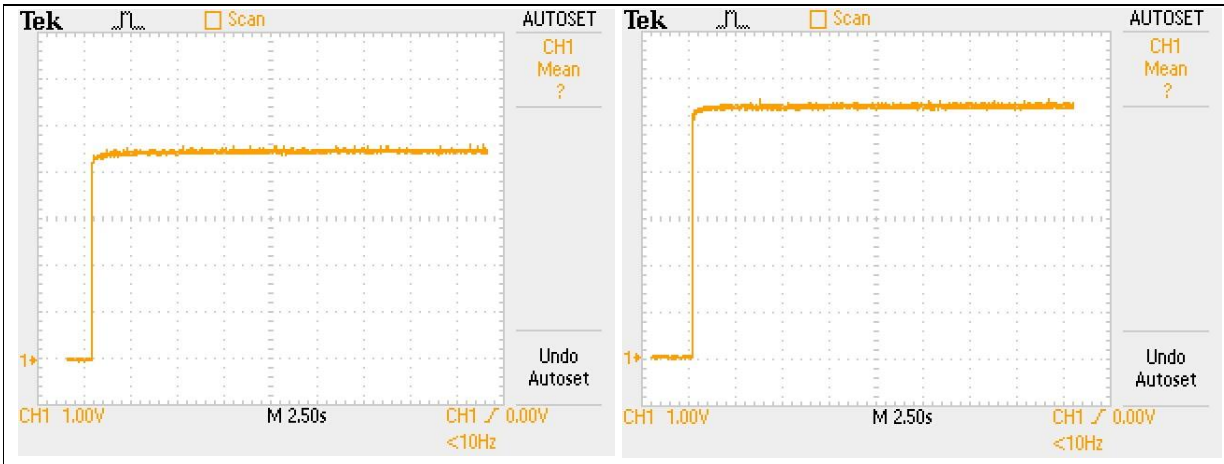


Figure 3 The signals recorded by Oscilloscope after exposed BSO crystal with continuous laser beam (633nm) with different degree of polarizer a(20), b(40), c(60), d(70).

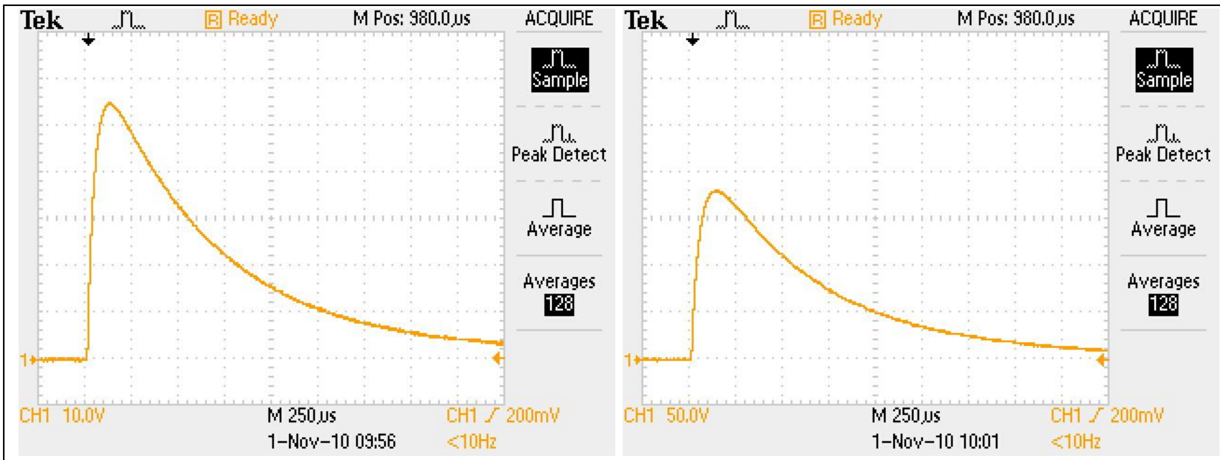


a b

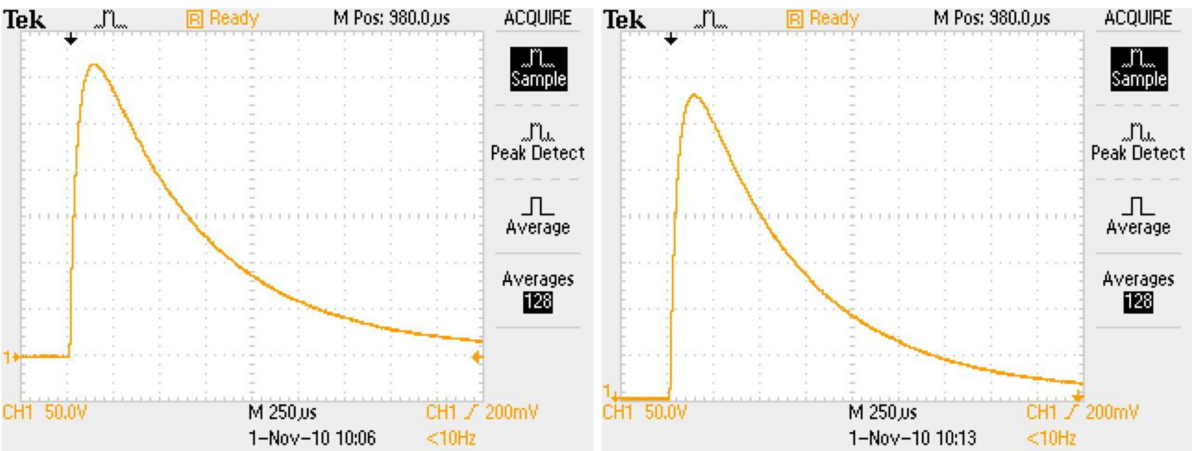


c d

Figure 4 The signals recorded by oscilloscope after exposed BSO crystal with continuous laser beam (532nm) with different degree of polarizer a(20), b(40), c(60), d(70).



a b



c d

Figure 5 The signals recorded by oscilloscope after exposed BSO crystal with pulsed - laser beam (532nm) with different degree of polarizer a(20), b(40), c(60), d(70)

4. Conclusions

After exposure BSO crystal by laser beams (532nm.633nm) it was shown that any increase in the polarizer degree of incident light caused increasing signals that measured by oscilloscope. The use of continuous laser beam of (532 nm) wavelength has more effect than the using of continuous He-Ne laser beam of (633 nm) wavelength**.** When a photorefractive Bi12SiO20 (BSO) crystal was exposed with high intensity pulsed-laser beams 532 nm , increasing the intensity of the process included a two-photon or two quantum (cascade)of light absorption, high intensity lead to transfer of electrons in the conduction band or to accumulate long-lived trapped band gap levels or returned to the valence band. Exposure of BSO crystal by pulsed -laser beams have more effect than continuous laser beams (532nm.633nm) dependent on the intensity.

5. Reference

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